HEALTHY FUTURES

Health, environmental change and adaptive capacity; mapping, examining & anticipating future risks of water-related vector-borne diseases in eastern Africa

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Future socioeconomic changes

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Table of Contents

List of terms and abbreviations

AR5	Assessment Report 5
CSO	Community supported organisation
DoW	Description of Work
CCAFS	Climate Change, Agriculture and Food Security
GEA	Global Environmental Assessments
GNP	Gross National Product
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
IAM	Integrated Assessment Models
IIASA	International Institute for Applied Systems Analysis
ILRI	International Livestock Research Institute
IPCC	Intergovernmental Panel on Climate Change
MEA	Millennium Ecosystem Assessment
NCAR	National Center for Atmospheric Research
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Co-operation and Development
PIK	Potsdam Institute for Climate Impact Research
PPP	Purchasing Power Parity
RCPs	Representative Concentration Pathways
SRES	Special Report on Emissions Scenarios
SSPs	Shared-Socioeconomic Pathways
UKCIP	United Kingdom Climate Impacts Programme
USA	United States of America
UNEP	United Nations Environment Program
VBD	Vector-Borne Diseases

Summary

Describing and quantifying the anticipated adverse health impacts of global climate change is necessarily an 'if-then' exercise that takes as given climatologists' estimates of the plausible range of greenhouse-induced climate change over the coming century. Next to that, information and development pathways on the future characteristics of population and related socio-economic characteristics are required. Scenarios are plausible and often simplified descriptions of how the future may develop. They are based on an internally consistent set of assumptions about key driving forces and relationships and allow for the capturing of uncertainties and systems complexity in a coherent manner. Both the sources and level of uncertainty in future drivers and the causality of changes are taken into account. We explored the usefulness of two scenario approaches: the new IPCC approach and the CCAFS approach. Additionally, we intended to provide consistent storylines as well as qualitative and quantitative information on the socio-economic dimensions of vulnerability (which have been identified in Task 4.1) and variables of interest to the disease modelling.

This deliverable report discusses scenario approaches in general and a review of currently available vulnerability scenarios. From this, it can be observed that vulnerability scenarios – even quantified – are a very new research domain. In the past, only globally available and simplified GDP and population estimations have been available. New scenarios developments, such as the CCFAS and IPCC will however provide in the future more detailed estimations, which can then be integrated into a spatial assessment of vulnerability.

Next to that we provide a detailed description of the scope and characteristics of the so called shared socio economic pathways (SSPs – currently developed by the climate change research community in collaboration with the IPCC) and the CCFAS approach. First available quantified indicators are presented and will be integrated later into the quantified assessment.

A core part is the presentation of the CCFAS storylines, developed for the CGIAR institutions. CCAFS is organizing regional scenarios development and use processes in East Africa, West Africa and South Asia together with stakeholders at the regional (sub-continental) scale in policy, private sector, NGOs and CSOs, media and research. These scenarios innovate on previous experiences of the CCAFS team and its supporting Scenarios Advisory Group members in a wide range of scenarios processes, in particular the multi-level scenarios work in the Millennium Ecosystems Assessment. The CCAFS scenarios for East Africa were developed over four workshops over 2010 and 2011 with a wide range of state and non-state stakeholders related to food security, environments and livelihoods in East Africa and are characterised through proactive vs. reactive governance and regional integration vs. the fragmented status-quo. During a workshop in November 2012 at ILRI in Nairobi, the CCAFS scenarios and key drivers were translated to the three target diseases of HEALTHY FUTURES.

Next to the qualitative storylines for the three target diseases, we aim to provide a quantitative assessment of key indicators in line with an estimation of future disease vulnerabilities. Currently different suitable models are being explored, which could provide such quantifications, at least at a country scale level. However, depending on the availability of data, a more spatially disaggregated approach will also be targeted.

1. Introduction

1.1. Rationale for using socio-economic scenarios in the context of climate change and vulnerability to vector-borne diseases

Many sources confirm that climate is already changing and it is projected to continue changing rapidly (e.g. IPCC 2007, IPCC 2012). Expected impacts of the observed climatic trends include reduced agricultural productivity (of food, feed and livestock products), higher disease prevalence (within crops, livestock and humans alike) and reduced fresh water availability (Thornton et al. 2009a, Thornton et al. 2009b). Adaptation is needed to mitigate the projected adverse impacts of climate change.

Climate projections for this century are becoming increasingly available with a high spatial and time resolution. But they are afflicted with uncertainties because of the unknown future emissions of greenhouse gases as well as natural variability and the imperfect understanding of climate science and modelling. Projected changes in terms of temperature, amount and timing of rainfall are hampered by uncertainties, but even less is known about the impacts of these changes (Kabubo-Mariara 2009). Thus, the evaluation of these climate impacts further increases the uncertainty of the results. Mahrenholz (2008) argues that in accordance with the precautionary principle, stakeholders should act in order to mitigate adverse effects of climate change even under the conditions of uncertainty by using methods of risk assessment and risk management and the inclusion of uncertainties should be a part of this risk assessment process.

Describing and quantifying the anticipated adverse health impacts of global climate change is necessarily an 'if-then' exercise, that takes as given climatologists' estimates of the plausible range of greenhouse-induced climate change over the coming century (McMichael. 1995). Health-impact models are typically based on climatic constraints on the development of the vector and/or parasite, and include limited population projections and non-climate assumptions (IPCC 2007). Health outcomes/impacts are, however, not only a function of climatic conditions but are also influenced by environmental (such as bio/physical geographical factors; e.g. climate conditions, soil, water, vegetation etc…), socio-economic and institutional factors. As e.g. the fourth assessment report of the IPCC (2007) states *"there are important differences between disease risk (on the basis of climatic and entomological considerations) and experienced morbidity and mortality. Although large portions of Europe and the USA may be at potential risk for malaria based on the distribution of competent disease vectors, locally acquired cases have been virtually eliminated, in part due to vector- and disease-control activities".* Some of the factors influencing vulnerability to climate change mentioned in the IPCC's report are: number of people, age structure of the population, the density of settlements, poverty, inequality, conflict, effective civic institutions. As the impacts of developmental, climatic and environmental scenarios on population health are important for health-system planning processes, they propose to project the incidence and geographical range of health outcomes under different climate and socio-economic scenarios.

Despite this advice, *"the use of scenarios to explore future effects of climate change on population health is at an early stage of development. Several modelling studies used the SRES climate scenarios, a few applied population scenarios, and none incorporated economic scenarios. Few studies incorporate adequate assumptions about adaptive capacity. The main approaches used are inclusion of current 'control capacity' in the observed climate–health function* (Rogers & Randolph 2000, Hales et al. 2002*) and categorisation of the model output by adaptive capacity, thereby separating the effects of climate change from the effects of improvements in public health"*(van Lieshout et al. 2004, Gage et al 2008, Huang et al. 2011). There is therefore no surprise that they

identify as one of their key research priorities: *"Development of health-impacts models for projecting climate-change-related impacts under different climate and socio-economic scenarios".* The work to be undertaken in WP4, task 4.4 of the HEALTHY FUTURES project is exactly responding to this.

Under the frame of the HEALTHY FUTURES project – and as outlined in the DoW – we intended to provide consistent storylines as well as qualitative and quantitative information on the socio-economic dimensions of vulnerability (which have been identified in Task 4.1) and variables of interest to the disease modelling (from WP3). These storylines were produced in close consultation with key stakeholders, policy makers, the global change community and others. Results from this task (4.4) and related deliverable (D4.4) will feed into the final risk and vulnerability maps developed in task 4.6. Within this task the aim is to provide a spatial assessment of risk of, and vulnerability to, disease burden and related impacts as a result of future changes in the frequency of the three target diseases.

In the frame of the HEALTHY FUTURES project we explored the usefulness of two scenario approaches: the new IPCC approach and the CCAFS approach. Chapter 2 and 3 provide some detailed description and its usefulness for HEALTHY FUTURES. In chapter 4 a comparison between the two approaches is presented and the reasons for building on the CCAFS scenarios for our purposes outlined. Chapter 5 then presents the application of the CCAFS scenarios to VBDs. The report ends with sections on the way forward and final conclusions.

1.2. The application of socio-economic scenarios in climate change, vulnerability and vector-borne diseases: evidence from literature

Scenarios are plausible and often simplified descriptions of how the future may develop. They are based on an internally consistent set of assumptions about key driving forces and relationships and allow for the capturing of uncertainties and systems complexity in a coherent manner. Both the sources and level of uncertainty in future drivers and the causality of changes are taken into account. Scenarios can be used for (a) strategic planning and decision-making based on expected outcomes and the trade-offs they imply, (b) directing scientific exploration and research and (c) raising awareness among policy-makers and other stakeholders of future disease impacts

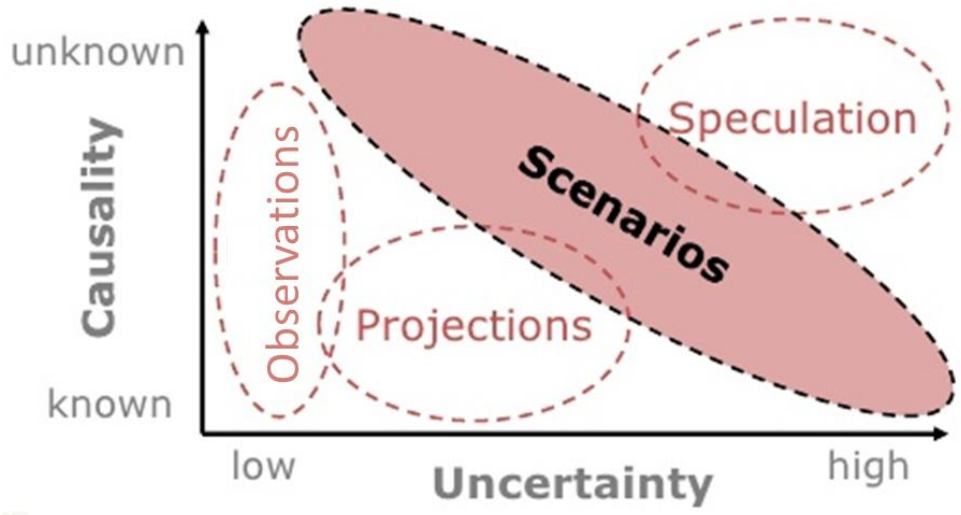

Fig.1: Uncertainty and causality in scenarios - adapted from Ingram & Ainsly (2010).

In contrast to prediction, scenario analysis does not focus on the most likely development but on an assessment of pathways of events under a set of key assumptions ('what if'?). These assumptions allow to set aside some of the uncertainties that complicate more exact statements on future behaviour. Earlier, scenarios have been defined as plausible descriptions of how the future might develop, based on a coherent and internally consistent set of assumptions ("scenario logic") about the key relationships and driving forces (e.g. rate of technology change, value change or prices) (Nakicenovic et al. 2000, de Vries & Petersen 2009). In the last 10–15 years, scenario analysis has become very popular in Global Environmental Assessments. Many GEAs now extensively use scenario analysis, such as IPCC's Assessment Reports (e.g. IPCC 2007), UNEP's Global Environmental Outlook (UNEP 2002, UNEP 2007), the International Assessment on Agricultural Knowledge, Science and Technology Development (IAASTD 2008) and the Millennium Ecosystem Assessment (MEA) (MA 2005).

Climate change scenarios mainly have the objective to model and predict future climate parameters and how they will change based on socioeconomic developments. In regard to integrated and concrete vulnerability scenarios, Moss et al (2010) recently highlighted the need for vulnerability scenarios in the context of impact studies and socio-economic drivers. *"This information is crucial for evaluating the potential of humankind to be affected by changes in climate, as well as for examining how different types of economic growth and social change affect vulnerability and the capacity to adapt to potential impacts"* (ibid.). They furthermore highlight the need for higher resolution spatial estimates on socio-economic parameters, as well as the need to apply approaches including quantitative and qualitative research. One of the first examples of applying socio-economic vulnerability scenarios has also been the report by UKCIP (2001).
A recent characterisation, applied also in the context of the IPCC AR5 on vulnerability scenarios is the following (IPCC/CIESIN 2012):

> *"Vulnerability Scenarios: Scenarios of demographic, economic, policy, cultural, and institutional characteristics are needed for evaluating the potential to be impacted by changes in climate as well for examining how future patterns of economic growth and social change affect vulnerability and the capacity to adapt. Many of the same socioeconomic factors that affect emissions also affect vulnerability and adaptive capacity and thus the underlying socioeconomic modelling must be coordinated."*

As vulnerability has also been defined in the context of the HEALTHY FUTURES projects as an integrated and complex phenomenon (see also IPCC 2012), it first needs to build on different available indicators. In the past, research has mainly been carried out on methodologies on downscaling specific socio-economic indicators (e.g. Gaffin et al. 2004, Grübler et al. 2006, van Vuuren et al. 2007). However, this does not specifically integrate the different indicators towards future vulnerability scenarios.
A first methodological approach has also been presented by Giannini et al. (2011), where future vulnerability predictions and cross-correlation with other socio-economic indicators with GNP and population estimations has been achieved. This provides an example, where different indicators have been combined towards an integrated and quantitative vulnerability assessment. A qualitative approach has been recently chosen by the Institute for Alternative Futures (2011) which developed storylines of future vulnerabilities in the USA. This approach built on drivers such economy & jobs, housing & neighbourhoods, education, government, environment & resources, food & diet, cultural, social & generational change, criminality & corrections, technology as well as web & communications. In total four scenarios have been developed (comeback, dark decades, equitable economy, creative communities) where the above mentioned drivers have been characterised in a narrative manner. Ravera et al. (2011) develop scenarios at the local level through a participatory approach. This also develops four sets of scenarios where future trends are being estimated. In such

a context the process of developing the scenarios as well as the involvement of local people in a participatory manner seems to be the unique characteristic.
Next to this research and outcome oriented approaches, handbooks have been developed to provide guidance on the assessment of vulnerability (Malone et al. 2004, UNDP 2010) in the context of climate change. However, it has to be clear that this approach reflects the notion of vulnerability used in the climate change research community, which sees vulnerability as a combination of the potential impact and the adaptive capacity. The guidebooks are also very generic and provide methods on how to translate this definition of vulnerability into the future.
A wide range of vulnerability scenarios exists in the context of transportation networks (Lu & Peng 2011), supply changes (Svensson2000) and water stress in the future (Vörösmarty et al 2000).

To sum up, the terminology of vulnerability scenarios is not something new. However, most examples comprise either a more qualitative and narrative approach and/or build on the 'older' approach of defining vulnerability as the combination of potential climate change impacts and adaptive capacity. Challenges have been specifically in the context of available future indicators in an appropriate scale range.

Under this frame we intend to further develop these existing approaches (a) towards a more integrative and recent definition of vulnerability and (b) as useful narratives specifically developed for the region and (c) further develop quantitative approaches which allow the integration of future disease model outputs and vulnerability estimation towards a risk assessment.

We therefore have built our work on the currently adapted IPCC scenario process working on representative concentration pathways (RCPs) and shared-socioeconomic pathways (SSPs). In a parallel process, the CGIAR research program on Climate Change, Agriculture and Food Security (CCFAS) has embarked on regional scenario building in their research areas: East-Africa, West-Africa and Indo-Gangetic Plains. Both scenario approaches are presented in the following sections.

2. The CCFAS approach

CCAFS is organizing regional scenarios development and use processes in East Africa, West Africa and South Asia together with stakeholders at the regional (sub-continental) scale in policy, private sector, NGOs and CSOs, media and research. These scenarios innovate on previous experiences of the CCAFS team and its supporting Scenarios Advisory Group members in a wide range of scenarios processes, in particular the multi-level scenarios work in the Millennium Ecosystems Assessment.

The CCAFS regional scenarios process aims:

1. to explore key regional socio-economic and governance uncertainties for food security, environments and livelihoods through integrated qualitative-quantitative scenarios describing futures up to 2030;

2. to use these scenarios with regional, national and local actors for strategic planning to explore the feasibility of strategies, technologies and policies toward improved food security, environments and livelihoods under different socio-economic and governance conditions.

The regional scenarios process plays a unique role in the context of food security, environments and livelihoods. It can help to articulate the transformational challenges that climate change poses by the complementary focus of the scenarios on socio-economic changes and uncertainties; through

the regional focus of the scenarios process and its links across scales, it provides a powerful tool for integrating the needs of a wide range of stakeholders to help identifying synergies and trade-offs for improved environmental health, rural livelihoods and food security in the face of an uncertain future. This cross-scale, cross-sector strategic futures work aimed for in CCAFS has rarely been done, and CCAFS is innovating across these boundaries in ways that provides guiding insights to similar efforts.

Developing scenarios
The CCAFS scenarios for East Africa were developed over four workshops over 2010 and 2011 with a wide range of state and non-state stakeholders related to food security, environments and livelihoods in East Africa. The process followed a number of steps:
The time horizon for the East Africa scenarios was set at 2030 since participants felt that this time horizon would allow for a useful context for planning at the regional level and a time frame across which fairly detailed narratives could be developed.

Identifying drivers of change
Stakeholders identified drivers of future change in the region, selecting those that were relevant for outcomes of food security, environments and livelihoods. These drivers were listed according to their importance and to the uncertainty associated with them. Several drivers were identified that were considered important but relatively certain over the 2010-2030 period. These are:

- *Population:* population growth is used as projected by the World Bank (ref). "Intrinsic" population growth based on fertility in different countries is predictable for 2030. This does not hold for population change due to immigration.

- *Climate change* – since climate models do not diverge strongly until after 2030, a 1 degree global average temperature rise by 2030 and increased variability were used as a certain driver across the four scenarios.

Two drivers were considered both the most relevant for future food security, environments and livelihoods - and the most highly uncertain. These are:

- *Regional integration:* will the East African countries integrate politically and economically, or will the fragmented status quo be maintained?

- *Mode of governance:* will governance by state and non-state actors in the region be characterized by a reactive or proactive stance?

These two uncertain drivers were used to structure the four scenarios. However, many other drivers were identified and used to inform each of the four scenarios.

Four scenarios
The CCAFS scenarios development process has resulted in a set of scenario narratives, associated estimates of consequences of the narratives for a number of indicators for food security, environments and livelihoods, and quantitative information linked to these indicators. Divided by two axes of uncertainty – regional integration and mode of governance – these four scenarios represent different worlds, each bound by their own combination of assumptions. The way in which these assumptions play out is naturally dependent on the ideas of the story writing groups and their representatives – the narratives represent only one of many ways in which these combinations of assumptions unfold. Care has been taken to make each scenario useful to prospective users. In that regard, useful means that each scenario poses challenges for those planning for the future, as well

as opportunities to explore new approaches and strategies. Some scenarios, such as the "Industrious Ants" scenarios, may have more "positive" elements than others such as "Sleeping Lions". However, it is a crucial function of the scenarios that they demonstrate that apparent successes for food security, environments and livelihoods in these scenarios breed new challenges and to realize that problematic situations could open up unforeseen opportunities.

The next sections present summarized narratives and cause-effect maps of the scenarios – focusing on accessibility rather than content overload with the view that the scenarios should be used and that there should be room for reinterpretation.

Scenario 1: Industrious Ants

This scenario is characterized by the slow but strong economic and political development of East Africa and proactive government actions to improve regional food security; however, there are costly battles with corruption and security is fragile as the region has to deal with new international tensions resulting from its assertion in the global political and economic arena. The region's focus away from export-only commercial crops causes some challenges to compete on the global market – and the region's dedication on regional self-reliance proves to be challenging when the great drought hits in the early 2020s – though by that time many state and non-state support structures are in place to help mitigate the worst impacts. Governments and non-state actors struggle to mitigate the environmental impacts of growing food and energy production.

		2020	2030	Why?
Economy and governance	Gross Domestic Product	+	+++	Broad development push for food security, environments, livelihoods
	Corruption index	-	--	Regional collaboration takes time to become effective
	Political stability	++	+++	National issues have to be worked out first
	Infrastructure	+	+++	Long-term investment
	Rural to urban population ratio	++	+++	Not extreme because of rural investment
Livelihoods	Poverty	--	--	Broad development push for food security, environments, livelihoods
	Equity	--	--	Equity decreases with rising GDP
	Access to healthcare	+	++	Broad development push
Food production and food security	Yields for rain-fed crops	++	+++	Effective support (tech and skills)
	Yields for irrigated crops	++	+++	Investment in production for regional consumption
	Area for rain-fed arable land	+++	++	Attempts to moderate expansion
	Area for irrigated arable land	+++	++	Attempts to moderate expansion
	Livestock numbers	+	*	Policies to mitigate livestock impacts
	Livestock yields	+	++	Investment in different animals, actors, production systems
	Agricultural production costs	-	--	More fair and transparent pricing
	Malnutrition	--	---	Focal point for government policies

	Dietary diversity	++	++	Focal point for government policies
Environments	Forest cover change	---	--	Governments/NGOs struggle with environmental governance
	Biodiversity	---	--	Governments/NGOs struggle

Tab.1: Characteristics and drivers of the Industrious Ants scenario

Scenario 2: Herd of Zebra

In this scenario, governments and non-state actors are dedicated to a push for development - but mainly through industry, services, tourism and agriculture for export. In terms of food security, environments and livelihoods there is limited action. Natural lands decline. East African economies are booming but the region suffers the consequences of a double vulnerability - to global markets and environmental change. Only when food insecurity becomes extreme after food import prices skyrocket at the time of the great drought in the early 2020s are actions taken to govern water resources and invest in climate-smart food production for regional consumption.

		2020	**2030**	**Why?**
Economy and governance	Gross Domestic Product	++	+++	Focus on industry, services, tourism, export agriculture
	Corruption index	++	++	New regional institutions become vehicles for corruption
	Political stability	-	+	Some initial conflicts over resources, later solved
	Infrastructure	++	+++	Investment for industry
	Rural to urban population ratio	+++	+++	Urbanization responds to investment sectors
Livelihoods	Poverty	-	-	Benefits of development spread unequally
	Equity	--	--	Equity decreases with rising GDP
	Access to healthcare	+	+	Benefits of development spread unequally
Food production and food security	Yields for rainfed crops	+	+	Not a government priority
	Yields for irrigated crops	++	++	Investment in export agriculture
	Area for rainfed arable land	+++	+++	Smallholders expand uncontrolled
	Area for irrigated arable land	+++	+++	Export agriculture
	Livestock numbers	+	++	Pastoralists decline under pressures, poultry grows
	Livestock yields	++	++	Ruminants decline but poultry grows
	Agricultural production costs	++	++	Rising fuel costs; ineffective governance
	Malnutrition	-	-	Benefits of development spread unequally

	Dietary diversity	++	++	Benefits of development spread unequally
Environments	Forest cover change	---	---	Ineffective environmental governance
	Biodiversity	---	---	Ineffective environmental governance

Tab.2: Characteristics and drivers of the Herd of Zebra scenario

Scenario 3: Lone Leopards

In this scenario, regional integration exists only on paper. In reality, governments and non-state actors are securing their own interests. In terms of food security, environments and livelihoods, the region initially seems to be heading towards catastrophe. However, after some years many regional state/non-state partnerships become very pro-active and, unburdened by tight regional regulations and supported by international relations, are able to achieve some great successes. Unfortunately, this is a hit-and-miss world because of the lack of coordinated efforts and key problems are ignored. Governments' inability to overcome regional disputes and collaborate becomes untenable when a major drought hits in 2020. This phenomenon pushes civil society, bolstered by international support, to demand radical change in governments. The change sticks in many cases, and for the better.

		2020	**2030**	**Why?**
Economy and governance	Gross Domestic Product	++	++	Profitable bilateral arrangements but differences between sectors and countries
	Corruption index	++	++	Failures as well as successes but lack of coordination
	Political stability	--	--	Conflicts over resources, trade
	Infrastructure	++	++	Patchwork improvement
	Rural to urban population ratio	+++	+++	Urbanization responds to investment sectors
Livelihoods	Poverty	++	-	State/non-state partnerships become effective
	Equity	--	--	Differences between countries but overall decrease with rising GDP
	Access to healthcare	*	++	State/non-state partnerships become effective
Food production and food security	Yields for rain-fed crops	+	++	Last decade sees NGO/CSO support
	Yields for irrigated crops	++	++	Investment in export agriculture
	Area for rain-fed arable land	+++	++	Some mitigation of expansion by state/non-state partnerships
	Area for irrigated arable land	+++	++	Some mitigation of expansion by state/non-state partnerships
	Livestock numbers	-	++	Pastoralists decline under pressures, poultry grows
	Livestock yields	++	++	Ruminants decline but poultry

				grows
	Agricultural production costs	++	-	Rising fuel costs; state/non-state partnerships have positive impacts later
	Malnutrition	+	--	Food security partnerships form in the last decade
	Dietary diversity	*	++	Food security partnerships form in the last decade
Environments	Forest cover change	---	++	Mobilization of regional and international NGOs
	Biodiversity	---	++	Mobilization of regional and international NGOs

Tab.3: Characteristics and drivers of the lone Leopards scenario

Scenario 4: Sleeping Lions

This scenario is all about wasted potential and win-lose games. Governments are reactive and self-interested –allowing foreign interests free reign in the region. This has devastating consequences for food security, livelihoods and environments in the region. Conflicts, protests and uprisings are common, and every time there is the promise of reform, it rarely materializes into any real change. Only at the very end of the period do the first signs of better governance emerge –but the future is still very uncertain. With no coordinated efforts to deal with climate impacts, the great drought of the early 2020s causes massive losses among the region's poor –and only communities' adaptive capacity and resilience, born out of decades of forced self-reliance, informal economies and the ability to share key knowledge can help mitigate some of the worst effects of this disaster.

		2020	**2030**	**Why?**
Economy and governance	Gross Domestic Product	++	+	Unproductive collaboration with external actors; lack of regional institutions
	Corruption index	+++	+++	Lack of regulations
	Political stability	--	--	Ineffective governance, no collaboration
	Infrastructure	++	+	Solely due to outside investment - but difficult due to lack of support
	Rural to urban population ratio	+	++++	Lack of rural livelihoods
Livelihoods	Poverty	++	+++	Little support from state/non-state actors
	Equity	---	---	Little support from state/non-state actors
	Access to healthcare	--	--	Little support from state/non-state actors
Food production and food security	Yields for rain-fed crops	--	--	Environmental degradation, failing support
	Yields for irrigated crops	+	+	Marginal increase for export crops
	Area for rain-fed arable land	+++	+++	Driven by need for food security

	Area for irrigated arable land	++	+++	Only export crops produced by external actors
	Livestock numbers	+	+	pastoralists decline under pressures, some poultry
	Livestock yields	+	+	marginal tech investment in poultry
	Agricultural production costs	+++	+++	rising fuel costs; artificial raising of prices
	Malnutrition	+++	+++	no efforts to mitigate; communities' expertise grows
	Dietary diversity	---	--	no efforts to mitigate; communities' expertise
Environments	Forest cover change	---	---	Environmental degradation unmitigated
	Biodiversity	---	---	Environmental degradation unmitigated

Tab.4: Characteristics and drivers of the Sleeping Lions scenario

3. The 'new IPCC approach'

Climate change scenarios have been a core basis for the assessment of future impacts within the IPCC assessment reports. The Special Report on Emissions Scenarios (SRES; Nakicenovic et al. 2000) published by the IPCC in 2000 paved the way for its application in various climate change oriented research and policy recommendations. The SRES projections included for the first time, 'storylines' or narratives of the future, which helped to get a better understanding and interpretation of the scenarios. The modelling results were based on a limited number of models and were implemented through an 'open process' of different modelling groups, where a strong cooperation and effort was achieved.

As the SRES approach was commissioned by the IPCC, it was decided in 2006 that the IPCC won't commission another set of scenarios while leaving this process to the research community. Currently it is intended that this process will provide the basis for the upcoming AR5 in 2013/2014. The conceptual approach for this new approach is in detail presented in Moss et al (2010), Kriegler et al (2010), Arnell et al (2011) and van Vuuren et al (2012). In the following the scenario approach is shortly presented and the shared socio-economic pathways outlined. Additionally first available results for the HEALTHY FUTURES target region will be presented and a list of currently available datasets provided. Chapter 5 proposes the way forward on how to integrate this approach and link it to the CCFAS approach.

3.1. Structure of the new scenario approach – representative concentration pathways (RCPs) and shared-socioeconomic pathways (SSPs)

The major difference within the establishment of the scenarios, as also outlined in Moss et al (2010), is shifting from a sequential process towards a parallel process in deriving different model results. The aim here is to shorten the time between the development of emissions scenarios and the use of the resulting climate scenarios in impact research, as well as to address the key information needs of users more effectively. Central elements are the representative concentration pathways (RCPs), which are characterised by specific emission scenarios from the literature as a pathway towards reaching each target radioactive forcing trajectory. These are four pathways characterised by their

radiative forcing in Wm^{-2} in 2100 (2.6, 4.5, 6.0, 8.5). For comparison the IPCC AR4 report defined the average radiative forcing since 1750 for the year 2005 with +1.6 Wm^{-2}. The political "two degree increase" approximately ranges around 2.5 Wm^{-2}.

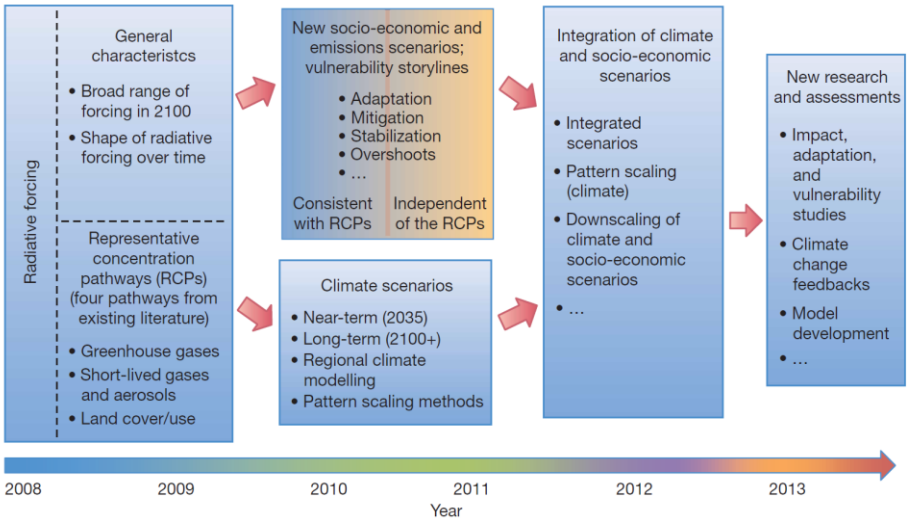

Fig.2.The new 'parallel' process (taken from Moss et al 2010)

The final RCPs have been selected out of a total of a range of 32 and were agreed on during an IPCC meeting in September 2007. It is important to know that the RCPs are intended as a starting point for input in climate modelling. So in this case they are not seen as forecasts nor policy recommendations. They thus constitute just the beginning of the parallel process of developing new scenarios for the IPCC's AR5. By doing so, the RCPs aim at providing a consistent analytical thread across communities.
In the following the four RCPs and the related modelling groups are shortly summarised (taken form http://www.iiasa.ac.at/web-apps/tnt/RcpDb/:

- **RCP 2.6:** The RCP 2.6 is developed by the IMAGE modelling team of the Netherlands Environmental Assessment Agency. The emission pathway is representative for scenarios in the literature leading to very low greenhouse gas concentration levels. It is a so-called "peak" scenario: its radiative forcing level first reaches a value around 3.1 W/m2 mid-century, returning to 2.6 W/m2 by 2100. In order to reach such radiative forcing levels, greenhouse gas emissions (and indirectly emissions of air pollutants) are reduced substantially over time. The final RCP is based on the publication by van Vuuren et al. (2007).
- **RCP 4.5:** The RCP 4.5 is developed by the MiniCAMmodeling team at the Pacific Northwest National Laboratory's Joint Global Change Research Institute (JGCRI). It is a stabilization scenario where total radiative forcing is stabilized before 2100 by employment of a range of technologies and strategies for reducing greenhouse gas emissions. The scenario drivers and technology options are detailed in Clarke et al. (2007). Additional detail on the simulation of land use and terrestrial carbon emissions is given by Wise et al (2009).
- The **RCP 6.0** is developed by the AIM modelling team at the National Institute for Environmental Studies (NIES), Japan. It is a stabilization scenario where total radiative forcing is stabilized after 2100 without overshoot by employment of a range of technologies and strategies for reducing greenhouse gas emissions. The details of the scenario are described in Fujino et al. (2006) and Hijioka et al. (2008).

- The **RCP 8.5** is developed by the MESSAGE modelling team and the IIASA Integrated Assessment Framework at the International Institute for Applies Systems Analysis (IIASA), Austria. The RCP 8.5 is characterized by increasing greenhouse gas emissions over time representative for scenarios in the literature leading to high greenhouse gas concentration levels. The underlying scenario drivers and resulting development path are based on the A2r scenario detailed in Riahi et al. (2007)

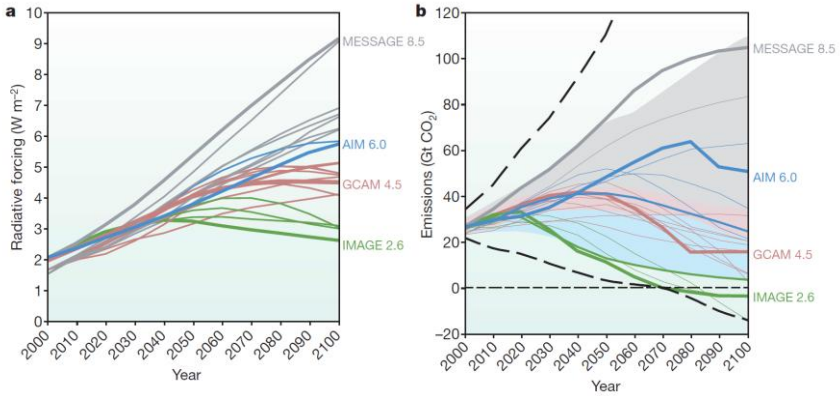

Fig. 3Representative concentration pathways (a) changes in radiative forcing to pre-industrial conditions as well as (b) energy and industry CO2 emissions for the RCP candidates (taken from Moss et al. 2010).

Parallel to the RCPs, currently the shared socio-economic reference pathways (SSP) are being defined. As outlined in Moss et al (2010) this should help to avoid time delays within the different modelling groups. The currently available key papers on the SSP are Arnell et al (2011), outlining the concept, as well as O'Neill et al (2012) providing a first draft overview of the associated storylines. Modelling results for the different SSPs are provided for different socioeconomic indicators on an IIASA hosted database, and are currently under review by the scientific community and will be updated frequently in the future (https://secure.iiasa.ac.at/web-apps/ene/SspDb/).
As outlined in Arnell et al (2011) a scenario describes a comprehensive description of the future of the human-climate system, including quantitative and qualitative information, whereas a pathway describes scenario components such as atmospheric concentration or development indicators. In our sense a vulnerability scenario would then describe future distributions and levels of vulnerabilities in a quantitative way (such as through the mapping of spatially-explicit integrated indicators) as well as a narrative describing the potential futures and uncertainties (qualitative assessment).

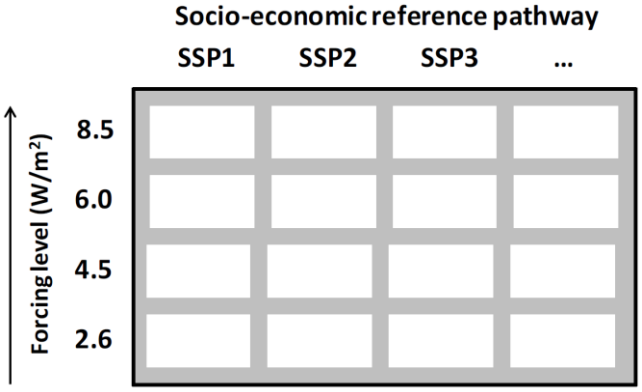

Fig.4 Scenario matrix architecture

The core idea of the new scenario approach is the so-called scenario matrix where the RCPs and different SSPs are being combined to develop this new scenario set. Each combination of an SSP and a radiative forcing level defines a family of macro-scale scenarios (see Fig. 4). As Arnell et al. (2011) outline the SSPs define the state of human and natural societies at a macro scale and have two 132 elements: a narrative storyline and a set of quantified measures that define the high-level state 133 of society as it evolves over the 21st century under the assumption of no significant climate 134 feedback on the SSP. This assumption allows the SSP to be formulated independently of a 135 climate change projection.

The SSPs are characterised by its increasing socio-economic challenges to mitigation and adaptation (see Fig. 5). One of the key aims of the scenario matrix architecture is to facilitate research and assessment that can characterize the range of uncertainty in mitigation efforts required to achieve particular radiative forcing pathways, in adaptation efforts that could be undertaken to prepare for and respond to the climate change associated with those pathways, and in residual impacts. These outcomes will depend on assumptions regarding future socio-economic conditions (Arnell et al 2011).

During a joint workshop held in Boulder in November 2011 (O'Neill et al 2012) narratives for five different SSPs has been jointly developed with different scientists. Key characteristic elements have been identified, to characterize a global socio-economic future for the 21st century as a reference for climate change analysis. It is therefore particularly important that the key elements are sufficient to differentiate SSPs from one another in terms of the socio-economic challenges they would present to mitigation and adaptation (O'Neill et al 2012). The key elements comprise population and human resources, economic development, human development, technology, lifestyles, environment and natural resources and policies and institutions.

The five narratives have been named and outlined as follows (taken from O'Neill et al 2012). The summary narrative is reflected here, whereas the full version is published in O'Neill et al (2012):

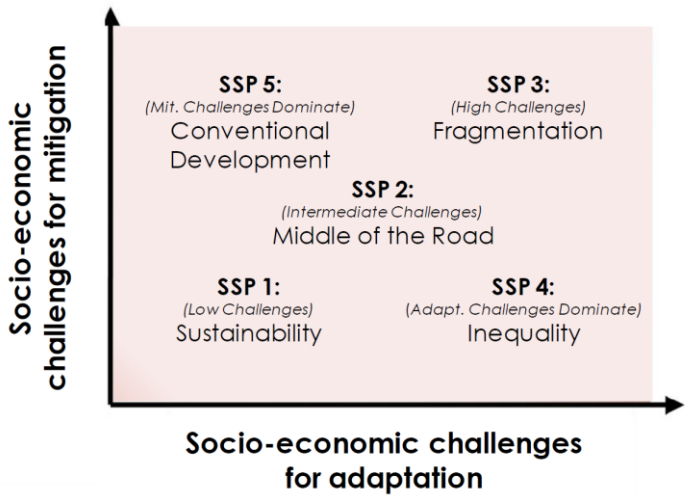

Fig. 5.Five SSPs, for which basic narratives were developed at the Boulder meeting. A sixth SSP that would be an alternative interpretation of SSP2 was proposed and discussed but not further developed (O'Neill 2012)

- **SSP 1: Sustainability**: This is a world making relatively good progress towards sustainability, with sustained efforts to achieve development goals, while reducing resource intensity and fossil fuel dependency. Elements that contribute to this are a rapid development of low-income countries, a reduction of inequality (globally and within economies), rapid technology development, and a high level of awareness regarding environmental degradation. Rapid economic growth in low-income countries reduces the number of people below the poverty line. The world is characterized by an open, globalized economy, with

relatively rapid technological change directed toward environmentally friendly processes, including clean energy technologies and yield-enhancing technologies for land. Consumption is oriented towards low material growth and energy intensity, with a relatively low level of consumption of animal products. Investments in high levels of education coincide with low population growth. Concurrently, governance and institutions facilitate achieving development goals and problem solving. The Millennium Development Goals are achieved within the next decade or two, resulting in educated populations with access to safe water, improved sanitation and medical care. Other factors that reduce vulnerability to climate and other global changes include, for example, the successful implementation of stringent policies to control air pollutants and rapid shifts toward universal access to clean and modern energy in the developing world.

- **SSP 2: Middle of the Road (or Dynamics as Usual, or Current Trends Continue, or Continuation, or Muddling Through)**: In this world, trends typical of recent decades continue, with some progress towards achieving development goals, reductions in resource and energy intensity at historic rates, and slowly decreasing fossil fuel dependency. Development of low-income countries proceeds unevenly, with some countries making relatively good progress while others are left behind. Most economies are politically stable with partially functioning and globally connected markets. A limited number of comparatively weak global institutions exist. Per-capita income levels grow at a medium pace on the global average, with slowly converging income levels between developing and industrialized countries. Intra-regional income distributions improve slightly with increasing national income, but disparities remain high in some regions. Educational investments are not high enough to rapidly slow population growth, particularly in low-income countries. Achievement of the Millennium Development Goals is delayed by several decades, leaving populations without access to safe water, improved sanitation, and medical care. Similarly, there is only intermediate success in addressing air pollution or improving energy access for the poor as well as other factors that reduce vulnerability to climate and other global changes.
- **SSP 3: Fragmentation (or Fragmented World)**: The world is separated into regions characterized by extreme poverty, pockets of moderate wealth and a bulk of countries that struggle to maintain living standards for a strongly growing population. Regional blocks of countries have re-emerged with little coordination between them. This is a world failing to achieve global development goals, and with little progress in reducing resource intensity, fossil fuel dependency, or addressing local environmental concerns such as air pollution. Countries focus on achieving energy and food security goals within their own region. The world has de-globalized, and international trade, including energy resource and agricultural markets, is severely restricted. Little international cooperation and low investments in technology development and education slow down economic growth in high-, middle-, and low-income regions. Population growth in this scenario is high as a result of the education and economic trends. Growth in urban areas in low-income countries is often in unplanned settlements. Unmitigated emissions are relatively high, driven by high population growth, use of local energy resources and slow technological change in the energy sector. Governance and institutions show weakness and a lack of cooperation and consensus; effective leadership and capacities for problem solving are lacking. Investments in human capital are low and inequality is high. A regionalized world leads to reduced trade flows, and

institutional development is unfavourable, leaving large numbers of people vulnerable to climate change and many parts of the world with low adaptive capacity. Policies are oriented towards security, including barriers to trade.

- **SSP 4: Inequality (or Unequal World, or Divided World):** This pathway envisions a highly unequal world both within and across countries. A relatively small, rich global elite is responsible for much of the emissions, while a larger, poorer group contributes little to emissions and is vulnerable to impacts of climate change, in industrialized as well as in developing countries. In this world, global energy corporations use investments in R&D as hedging strategy against potential resource scarcity or climate policy, developing (and applying) low-cost alternative technologies. Mitigation challenges are therefore low due to some combination of low reference emissions and/or high latent capacity to mitigate. Governance and globalization are effective for and controlled by the elite, but are ineffective for most of the population. Challenges to adaptation are high due to relatively low income and low human capital among the poorer population, and ineffective institutions.
- **SSP 5: Conventional Development (or Conventional Development First):** This world stresses conventional development oriented toward economic growth as the solution to social and economic problems through the pursuit of enlightened self interest. The preference for rapid conventional development leads to an energy system dominated by fossil fuels, resulting in high GHG emissions and challenges to mitigation. Lower socio-environmental challenges to adaptation result from attainment of human development goals, robust economic growth, highly engineered infrastructure

3.2. Indicators for SSPs - Selected visualisation for East Africa

The definition and final agreement of the storylines of the SSPs is ongoing at the moment within the scientific community and are expected to be published also in the IPCC AR5. However, first model results on selected socio-economic indicators have been currently provided by the different modelling teams.

For each SSP a single population and urbanization scenario, developed by the International Institute for Applied Systems Analysis (IIASA) and the National Center for Atmospheric Research (NCAR), is provided. For GDP, three alternative interpretations of the SSPs by the teams from the Organisation for Economic Co-operation and Development (OECD), the International Institute for Applied Systems Analysis (IIASA) and the Potsdam Institute for Climate Impact Research (PIK) have been developed. The GDP projections are based on harmonized assumptions for the interpretation of the SSP storylines in terms of the main drivers of economic growth. They differ however with respect to the employed methodology and outcomes (taken from https://secure.iiasa.ac.at/web-apps/ene/SspDb/). A supplementary note on the characteristics of the data is also available (see https://secure.iiasa.ac.at/web-apps/ene/SspDb/static/download/ssp_suplementary%20text.pdf).

An overview of currently available variables is presented below as well as examples on selected variables (Fig. 6 – Fig. 10) and SSPs. As the data is only preliminary and draft, a more detailed discussion is avoided.

Population

- Provided by IIASA
- Unit: Millions
- 5-year intervals (2010 – 2100)
- Age groups (5-year intervals, from 0 – 100+)
    - Gender (male/female)

    - Education level
        - No education
        - Primary Education
        - Secondary Education
        - Tertiary Education
- Historic data:
    - WPP2010, WUP2009, World Bank (WDI)
    - Unit: Millions
    - 5-year intervals (1960 – 2010)
    - Only total numbers (no gender, age, education)

GDP

- Provided by IIASA, PIK and OECD
- Unit: Billion US$2005/yr
- 5-year intervals (2010 – 2100)
- Gross Domestic product (GDP), purchasing power parity (PPP)
- Historic data:
    - World Bank (WDI)
    - Unit: Billion US$2005/yr
    - 5-year intervals (~1980 – 2010)
    - Gross Domestic product (GDP), purchasing power parity (PPP)

Urbanization

- Provided by NCAR
- Unit: Percentage
- 10-year intervals (2010 – 2010)
- Population with urban share (percentage of population living in urban areas)
- Historic data
    - WUP2009
    - Unit: Percentage
    - 5-year intervals (1960-2010)
    - Population with urban share (percentage of population living in urban areas)

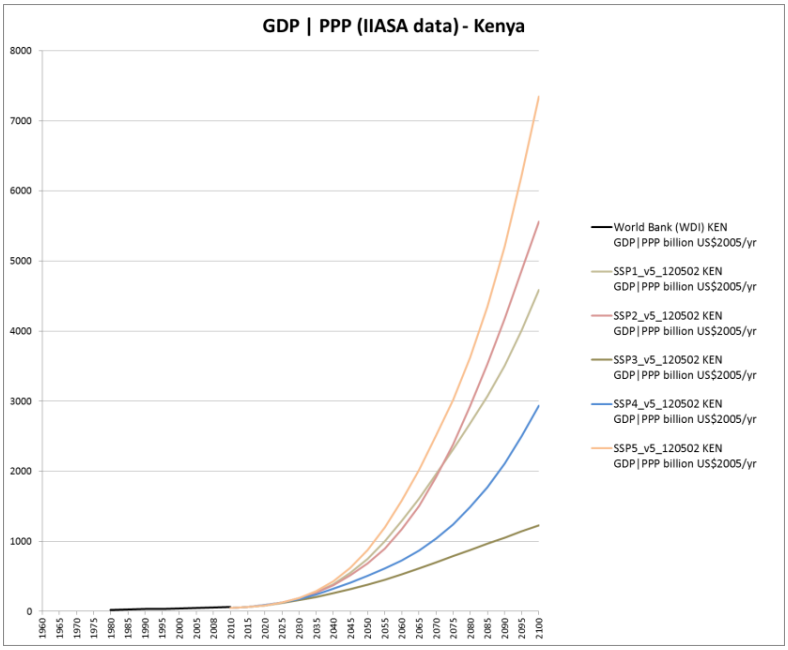

Fig.6. GDP and associated SSPs for Kenya

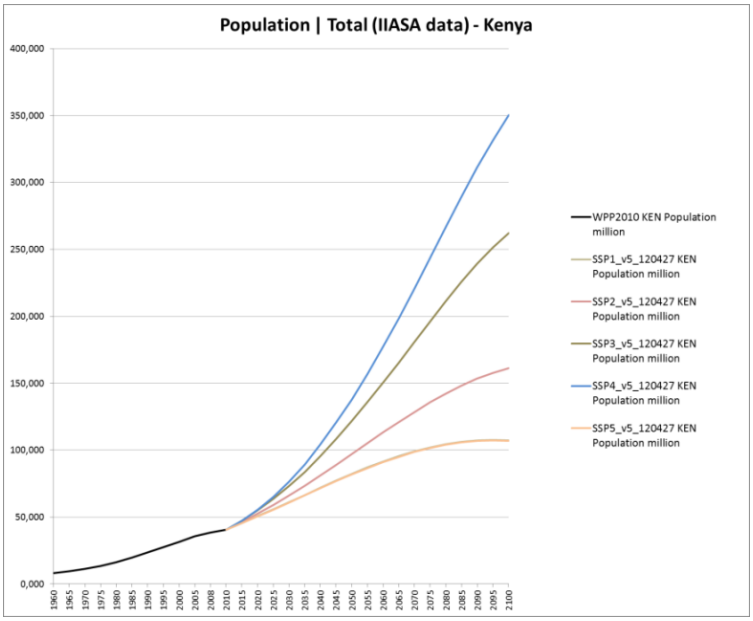

Fig.7. Population development (total) and associated SSPs for Kenya

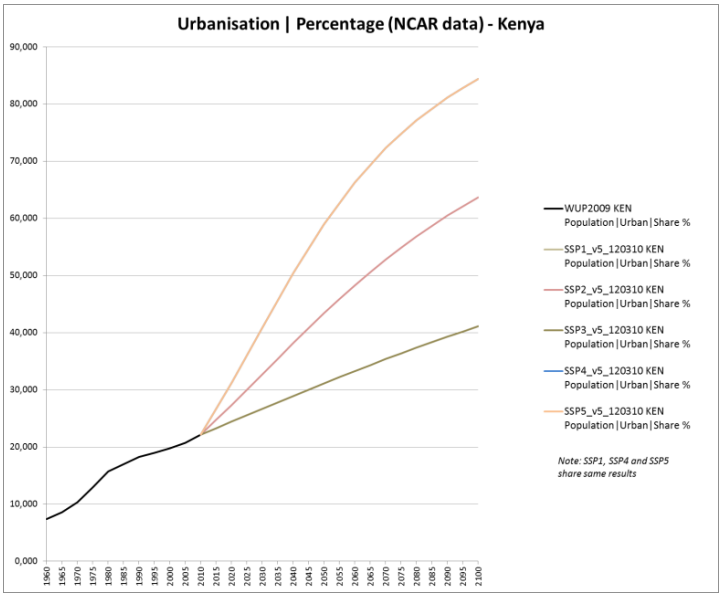

Fig.8. Population development (total) and associated SSPs for Kenya

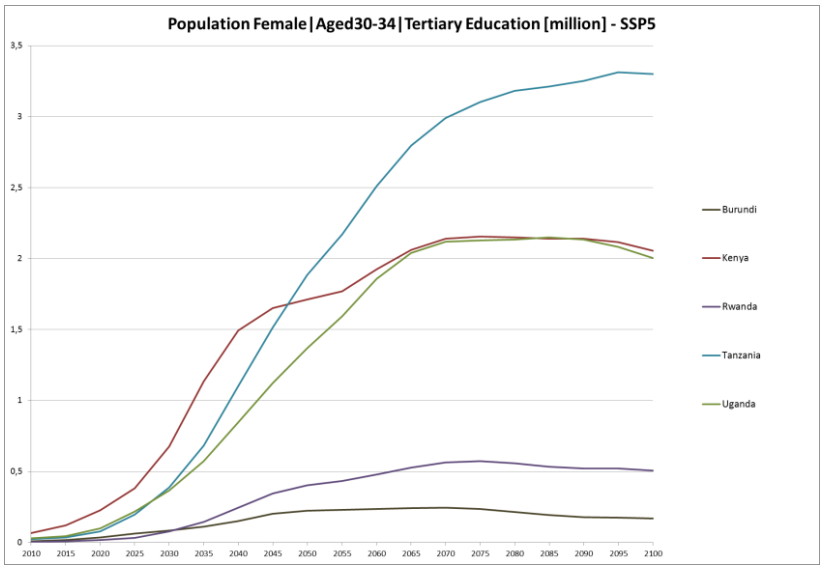

Fig.9. Comparison of the five HF target countries in regard to the future development 30-34 aged women with tertiary education based in the SSP5

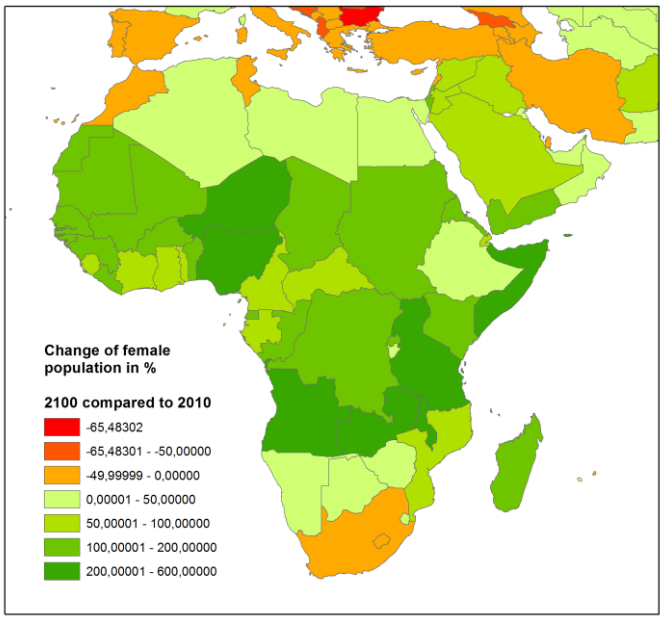

Fig. 10 Change of female population following the SSP1 scenario between 2010 and 2100

4. Benchmarking of the two approaches in regard to socio-economic scenarios

In this section we compare the storylines, approach and the main assumptions behind the scenarios of the CCAFS and IPCC approach.

4.1 General comparison

	CCAFS	IPCC	Main overlaps and differences
Scope - geographic	East-Africa	Global, current draft data is available at country level	Different focus on the regional vs. global level. However global level data can be used also for regional assessments
Objectives	-Exploratory, i.e. to capture uncertainties and challenges for regional food security, environment and livelihoods - To feed in strategic visioning exercises	- Provide a new scenario approach to be usable for the climate modellers, integrated assessment modelling and impact, adaptation and vulnerability analysis (in particular for IPCC 5AR) - Will serve as a follow-up to the SRES scenarios	IPCC focuses more on a wider domain in the climate change context, whereas the CCAFS approach has been developed for the more specific 'agricultural' focus
Approach	- Participatory storylines - Quantification through modelling	- Development of storylines, characterised by the challenges to mitigation and adaptation - Done within the scientific community - IAM provides models	CCAFS is more tight to the region and reflects regional characteristics, whereas the IPCC approach provides global level data

		results on different socio-economic variables	
Results	Qualitative storylines + quantified indicators	Qualitative storylines + quantified indicators	Both the IPCC and CCAFS approaches provide a range of newly developed socio-economic indicators
Type[1]	Deterministic, process oriented, both qualitative and quantitative, explorative	…, mix of explorative and policy-oriented	
Big +'s	Broad partnership: Oxford university, CGIAR, regional and local partners ensuring long-term support and application in a multitude of fields Participatory process generated shared engagement and relationships Strongly anchored in the region	Will be the next scenario approach after the SRES; It is also currently applied in the HF consortium through the RCPs and related climate modelling; and provides opportunity to be on the 'frontier' of current research efforts on applying this new scenario approach	Both are community driven and the CCFAS scenario people are also involved in the IPCC approach
Challenges			New approaches, therefore uncertainties in model results and its application; Availability of quantified, disaggregated data
Opportunities	Designed to support regional decision-making. Support from the CCAFS scenarios team for further development and quantification	Contribute to this new process which will be used widely in the future as it is a common approach of the global climate change research community	
Treatment of climate policies	Non	Implemented through a second "policy intervention" axis in the scenario matrix	

Tab.5: Comparison of the CCAFS and new IPCC approach

An important (but not always clear-cut) distinction between the scenarios is the *explorative scenario* and the *policy-scenario* approach. The first is mostly oriented at strategic questions, exploring possible futures. The second approach focuses on the impact of specific policy options and is particular useful if policy targets have been formulated. The CCAFS scenarios claim to be fully explorative, whereas the SSPs combine elements of the two approaches. It is done in the form of a

[1] *The typology here follows van Vuuren et al (2012b). They distinguish between probabilistic & deterministic, process & product oriented, qualitative and quantitative, explorative and normative*

scenario matrix with one axis representing different policy interventions and a second axis representing different storylines (van Vuuren et al., 2012b).

4.2 Scenario families

Van Vuuren et al. (2012) introduce the term "scenario family" to allow for simpler comparison across different sets of scenarios and assessments. A scenario family denotes a set of scenarios in the literature that seem to share a very similar scenario storyline or logic (i.e. basic underlying assumption) resulting as well in a similar kind of quantification. They describe the following six scenario families: (1) the economic-technological optimism/conventional markets scenarios, (2) the reformed market scenario, (3) the global sustainability scenario, (4) the regional competition/regional markets scenarios, the (5) regional sustainable development scenarios, (6) and the business-as-usual/intermediate scenarios. Table 3 summarises key assumptions for each of these families in very general terms. Where differences within a set of scenario families exist, broad ranges are indicated.

	Economic optimism	Reformed markets	Global SD	Regional competition	Regional SD	Business-as-usual
Main objectives	Economic growth	Various goals	Global sustainability	Security	Local sustainability	Not defined
Economic development	Very rapid	Rapid	Ranging from slow to rapid	Slow	Ranging from mid to rapid	Medium (globalisation)
Population growth	Low	Low	Low	High	Medium	Medium
Technology development	Rapid	Rapid	Ranging from mid to rapid	Slow	Ranging from slow to rapid	Medium
Environmental protection	Reactive	Both reactive and proactive	Proactive	Reactive	Proactive	Both reactive and proactive
Trade	Globalisation	Globalisation	Globalisation	Trade barriers	Trade barriers	Weak globalisation
Policies and institutions	Policies create open markets	Policies reduce market failures	Strong global governance	Strong national governments	Local steering; local actors	Mixed

Table 6. Key assumptions in different 'scenario families' (adapted from van Vuuren et al (2012b))

Each 'van Vuuren' family has elements that link to at least one of the four CCAFS scenarios. However, the 'van Vuuren' families make too many assumptions that relate specifically to a global level to leave room for interpretation and adaption to a more regional level. In this regard, the IPCC SSPs leave more room for downscaling. Because of their global focus, the 'van Vuuren' scenario families do not include uncertainty related to regional integration. This uncertainty is especially important when developing scenarios for regions where political stability and regional relations are highly uncertain.

Below you'll find rough match-ups between the SSPs and the CCAFS scenarios:

- Industrious Ants: Between Global regional sustainable development and regional sustainable development.
- Herd of Zebras: Economic optimism and Business-as-usual. Herd of Zebras remains more sceptical towards the future that the Economic optimism scenario poses.
- Lone Leopards: A combination of Regional sustainable development and Regional competition.
- Sleeping Lions: A combination of Regional competition and Business-as-usual.

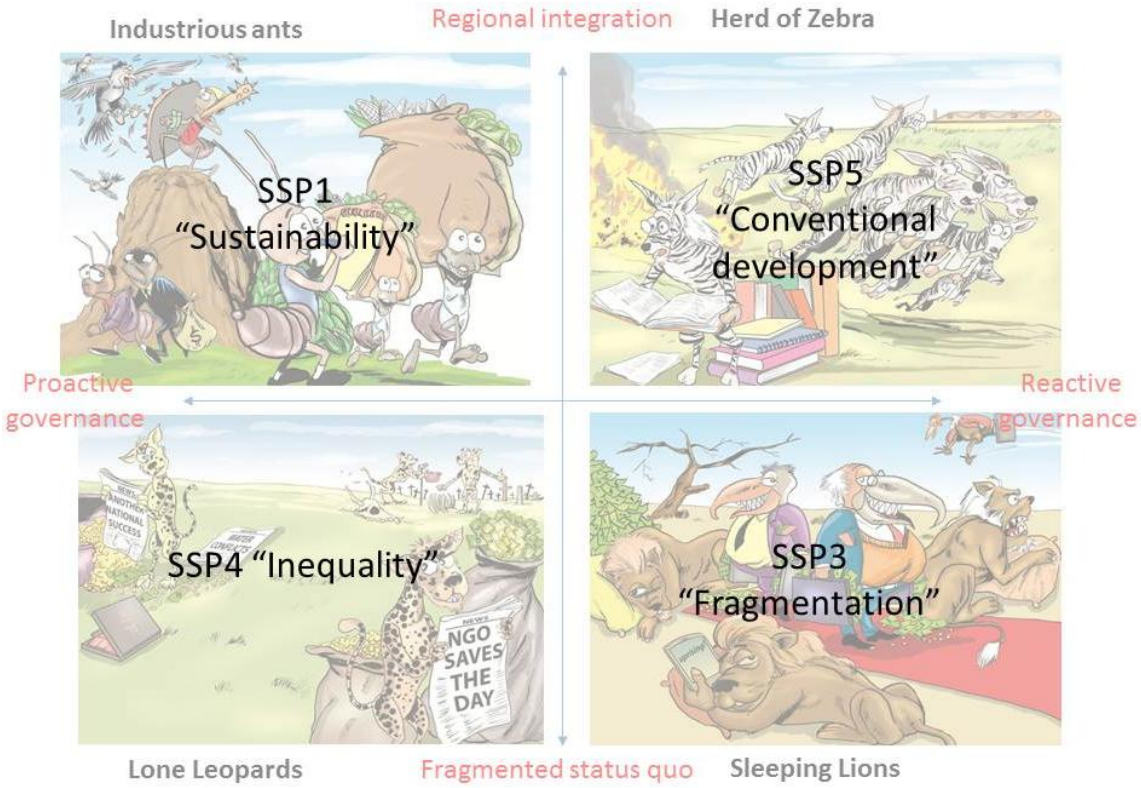

Fig. 11.Visual comparison of the SSPs and the CCAFS scenarios for Eastern Africa

The IPCC SSPs show a much better potential to be linked to the CCAFS scenarios. As the purpose of these SSPs is to appeal to a broad range of end-users and to be multi-applicable at different spatial and temporal levels, this is clearly reflected in their capacity to connect to the CCAFS scenarios. The piece below is a piece written up by Kasper Kok (personal communication), CCAFS Scenarios Leader and member of the SSP team, and shows how the SSPs and the CCAFS scenarios link up.

- Sleepy Lions: very good match with SSP3 ("Fragmentation"). Many processes that are assumed in SSP3 are likewise assumed to happen in East Africa. This doom scenario seems plausible at global and regional levels.
- Herd of Zebras: good match with SSP5 ("Conventional Development"). Both scenarios assume a strong focus on economic development on the expense of social and environmental issues. Yet, the long-term outlook of SSP5 is more positive than in Herd of Zebras.
- Lone Leopards: contains elements of SSP4 ("Inequality"). Both scenarios assume a widespread inequality with an important role for those that have proactive and visionary strategies. Yet, contrary to the Lone Leopards, SSP4 assumes a proactive role of the elite that is effectively managing global issues. While those are not necessarily contradicting, the (dis)similarities need to be studied further.
- Industrious Ants: contains elements of SSP1 ("Sustainability"). Both scenarios assume a general strive for a more sustainable world. The crucial difference is that in SSP1 this transformation succeeds, while in Industrious Ants, important issues remain.

5. The application of the scenarios in the context of VBDs

5.1. Introduction

Problems around diseases and food insecurity for vulnerable rural communities in the developing world go hand in hand. So, too, do the impacts of government policies and strategies of non-state actors focusing on health care and food. Both issues face many similar future uncertainties – both of an economic and political nature (e.g. migration, funds for treatment, conflicts, uneven development etc.) as well as biophysical change (e.g. climate change, ecosystem degradation), with different but related impacts. The CCAFS scenarios with their regional food security focus seemed to be best suited for our exploration of possible futures of vector-borne diseases in Eastern Africa. They were therefore selected as the basis for our assessments of future disease impacts and vulnerability. However, besides this suitability, the so-called new IPCC approach will also be further applied in this context, of having a clear link to the climate model results carried out in HEALTHY FUTURES as well of not losing the opportunity to contribute to this new development.

In order to do so, we organized a stakeholder workshop to adapt the CCAFS storylines to the disease context. In a next step these will be quantified through the use of integrated models. Both the qualitative and quantitative information will finally feed into the vulnerability assessments and decision support system.

5.2 Stakeholder consultation on scenarios and vector-borne diseases in eastern Africa

On 6th November 2012, a stakeholder consultation was organized at the ILRI campus in Nairobi with the specific aim of looking at potential futures of vector-borne diseases in East Africa. The workshop brought together experts of different disciplines and disease focus to discuss future scenarios of socio-economic development in the region and its implications for the spread and control of vector-borne diseases. Particular emphasis was thereby given to the drivers of specific importance to malaria, schistosomiasis and RVF. Eighteen participants from nine different organizations and six countries participated in this meeting (Annex 1).

The meeting developed an inventory of interventions to tackle the diseases – such as the analysis of rainfall information through mobile phone networks as an early warning system for Malaria, including disease risks in livestock insurance programs, the introduction of non-susceptible animals and the pairing of water-related disease mitigation policies with irrigation schemes.

Then, the participants discussed key uncertainties for the diseases, many of which related to food insecurity, agricultural livelihoods and environmental change – linking them strongly to the CCAFS scenarios. Examples are the uncertain future of pastoralists and the double-edged link between poverty (fewer livestock but less capacity to cope) and Rift Valley Fever. Similarly, better regional integration in East Africa might improve food trade but also allow for more opportunities for disease transmission across borders.

Inputs generated by the experts in this meeting about how the CCAFS scenarios might affect the future of these diseases are feeding into modeling and analysis of the diseases and their links to food, environments and livelihoods by the Healthy Futures project and its CGIAR partners. These results will be used to test the feasibility of interventions.

5.3. CCFAS narratives on vector-borne diseases

In the following the narratives of the CCFAS scenario as well as the results deriving from the stakeholder consultation are presented. We present again the general CCAFs scenario characteristics and the consequences for vector-borne disease. In Annex 2 a general overview is provided on the CCAFS scenario (PowerPoint presented at the workshop) as well as the translation sheet deriving from the workshop (Annex 3).

5.3.1. Scenario 1: Industrious Ants

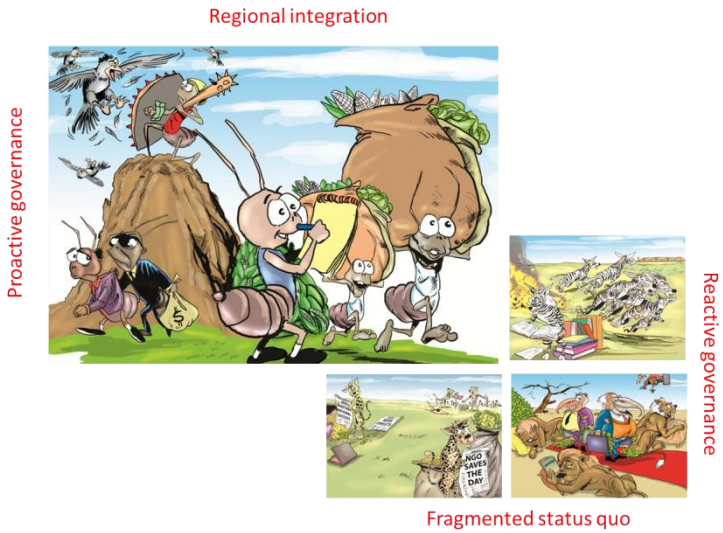

Fig. 12.Industrial Ants scenario

General narrative:
This scenario is characterized by the slow but strong economic and political development of East Africa and proactive government actions to improve regional food security; however, there are costly battles with corruption and security is fragile as the region has to deal with new international tensions resulting from its assertion in the global political and economic arena. The region's focus away from export-only commercial crops causes some challenges to compete on the global market – and the region's dedication on regional self-reliance proves to be challenging when the great drought hits in the early 2020s – though by that time many state and non-state support structures are in place to help mitigate the worst impacts. Governments and non-state actors struggle to mitigate the environmental impacts of growing food and energy production.

Vector borne diseases:
Investments in education and the alleviation of poverty and malnutrition pay off in this scenario in many ways, including in the reduction of the vulnerability of the rural poor to vector-borne diseases. While both rural and urban areas develop and populations increase, better disease prevention and treatment programs, early warning systems and better understanding of disease risks become a new standard. Regional integration leads to fewer conflicts that might drive up vulnerability to VBDs. For malaria, though susceptibility and fatal consequences go down, increased regional mobility has significant impact on the disease. Schistosomiasis cases go down because of education and increasing awareness, accompanied with infrastructural improvements to waste management, influencing customs around water use, the availability of jobs that do not involve natural water, and water safety measures. Rift Valley Fever cases are changed by new sanitary regulations for animals, the need to destroy infected livestock, better access to veterinary services. Mobility for pastoralists is highest in this scenario due to relaxed regional regulations.

5.3.2. Scenario 2: Herd of Zebra

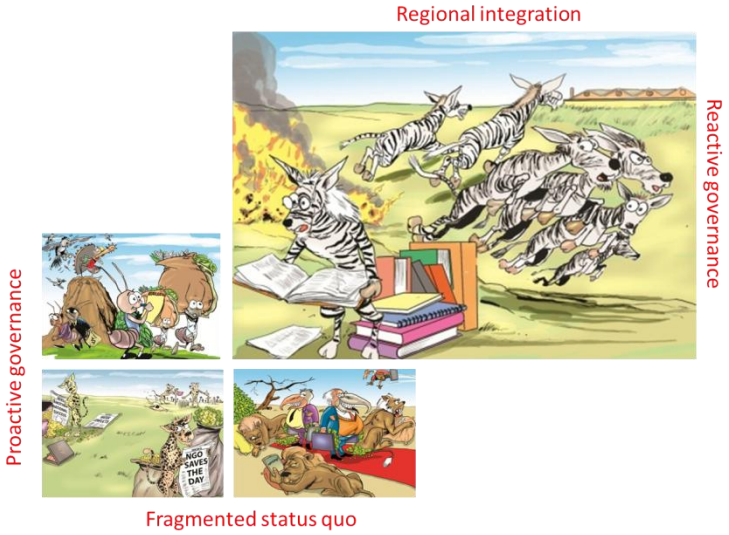

Fig. 12.Herd of Zebra scenario

General narrative:
In this scenario, governments and non-state actors are dedicated to a push for development - but mainly through industry, services, tourism and agriculture for export. In terms of food security, environments and livelihoods there is limited action. Natural lands decline. East African economies are booming but the region suffers the consequences of a double vulnerability - to global markets and environmental change. Only when food insecurity becomes extreme after food import prices skyrocket at the time of the great drought in the early 2020s are actions taken to govern water resources and invest in climate-smart food production for regional consumption.

Vector borne diseases:
In this scenario, increases in the availability of education are limited to the middle and upper classes, and very oriented toward business skills – while the type of education needed to help vulnerable communities deal with vector-borne diseases is largely absent. Later in the scenario the increasing wealth of the region spills over into some more availability of basic education. Similarly, malnutrition and poverty among the vulnerable is still common, but after 2030 some spillover effects of the growing economy are felt. Health care in the forms of disease prevention and treatment follows a similar pattern. Migrations to the cities are massive, leading to ever-expanding shantytowns which expose inhabitants to disease. Water resource development is largely driven by private sector interests and happens more or less uncoordinated so that each country features its own projects.
The movement away from jobs on the farm has consequences for the spread of vector-borne diseases. Work in commercial agriculture increasingly involves work with water, but this water has been cleaned (e.g. through heat treatment, or with molluscicide, etc.). Intensive livestock farming combined with little regulation about pastoralist movements affects the spread of Rift Valley Fever, though the dwindling numbers of pastoralists still make livestock mobility go down in absolute numbers.

5.3.3. Scenario 3: Lone Leopards

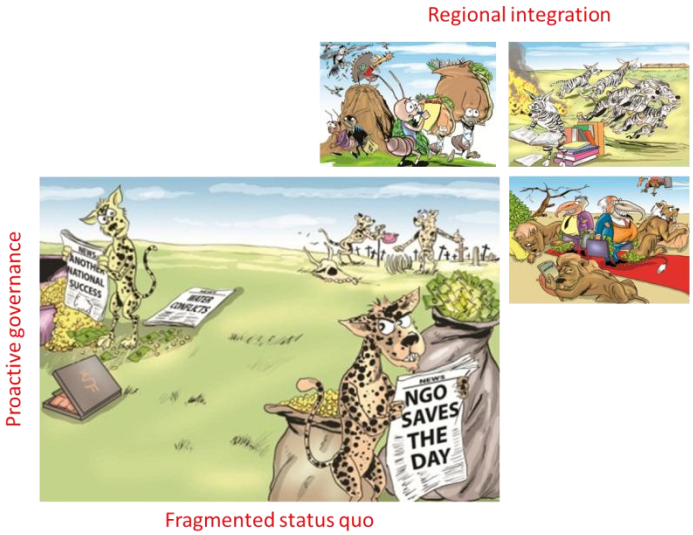

Fig. 13.Lone Leopards scenario

General narrative:
In this scenario, regional integration exists only on paper. In reality, governments and non-state actors are securing their own interests. In terms of food security, environments and livelihoods, the region initially seems to be heading toward catastrophe. However, after some years many regional state/non-state partnerships become very pro-active and, unburdened by tight regional regulations and supported by international relations, are able to achieve some great successes. Unfortunately, this is a hit-and-miss world because of the lack of coordinated efforts and key problems are ignored. Governments' inability to overcome regional disputes and collaborate becomes untenable when a major drought hits in 2020. This phenomenon pushes civil society, bolstered by international support, to demand radical change in governments. The change sticks in many cases, and for the better.

Vector borne diseases:
Education first stagnates and then, after various civil society groups work with governments to improve this situation, slowly gets better and leads to more informed people regarding vector-borne diseases. Similarly, malnutrition and poverty are alleviated to a degree in most parts of East Africa. However, the fragmented region struggles with instability in this regard. Some efforts are made to alleviate the suffering of rural communities, but these are not substantial enough to keep them from moving to the cities. Health care and information is pushed in many ways by civil society organizations, though their lack of coordination sometimes makes for a range of diverse messages being spread.
Because of tight laws around migration and trade, the mobility of vector-borne diseases is limited. Contact with water is very diverse – many change from work with natural water to more urban jobs, and water safety improves where it is recognized as an issue, but this trend is not universal. Concerning Rift Valley Fever, commercial rangelands are expanding and livestock numbers grow, adding to disease risks in the absence of overarching regulation.
Schistosomiasis will decline in some areas as access and reliance on open water bodies will decrease. However on the other side, increased population movements that cycle from rural to city locations will potentiate the infection as people will not necessarily seek treatment if they are in an area where there is currently no schistosomiasis.

5.3.4. Scenario 4: Sleeping Lions

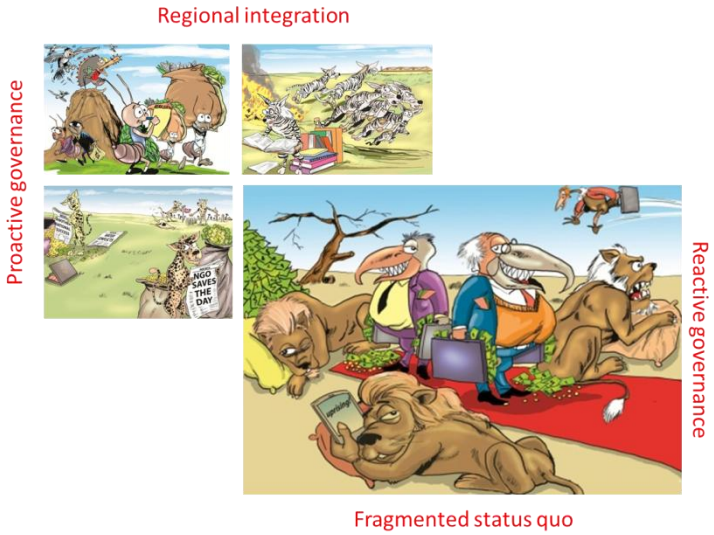

Fig. 14.Sleeping Lions scenario

General narrative:
This scenario is all about wasted potential and win-lose games. Governments are reactive and self-interested – allowing foreign interests free reign in the region. This has devastating consequences for food security, livelihoods and environments in the region. Conflicts, protests and uprisings are common, and every time there is the promise of reform, it rarely materializes into any real change. Only at the very end of the period do the first signs of better governance emerge – but the future is still very uncertain. With no coordinated efforts to deal with climate impacts, the great drought of the early 2020s causes massive losses among the region's poor – and only communities' adaptive capacity and resilience, born out of decades of forced self-reliance, informal economies and the ability to share key knowledge can help mitigate some of the worst effects of this disaster.

Vector borne diseases:
Improvements in education are largely absent and education numbers are barely prevented from collapsing. With growing populations, increasing food prices and the lack of any effective action to deal with these issues, malnutrition and poverty for vulnerable rural communities increase dramatically. As a result, the rural poor emigrate out to the cities in large numbers, giving up their previous lives as smallholder farmers. Encroachment by the poor on wetlands exposes them to water-borne diseases. Water resource development is largely absent. Civil societies are not effective in dealing with these issues – many of them serve as unorthodox arms of various self-centered players in governments. Health care remains the privilege of the middle classes and the wealthy elite. Donor funds for health care are cut in response to long standing problems with corruption. Transport is limited in the region due to degenerating infrastructure. Land grabbing decreases the mobility of pastoralists. There could be less contact with water through work because of the absence of investment in rural jobs. However, there is a slight uncertainty to that as people may be driven to exploit natural sources of income, e.g. fishing or water harvesting without increasing their livelihood conditions. In addition, the scarcity of water resources increases the need for the poor to get in contact with unsafe natural water.
Schistosomiasis will increase unless there will be sustained effort to either water treatment, a change in human behavior, better access to improved medicines or better latrines, sewerage systems etc.

5.4. Way ahead for quantitative scenarios

Next to the qualitative storylines for the three target diseases, we aim to provide a quantitative assessment of key indicators in line with an estimation of future disease vulnerabilities. Currently different suitable models are being explored, which could provide such quantifications, at least at a country scale level. However, but depending on the availability of data, a more spatially disaggregated approach will also be targeted.

In relation to the CCAFS scenarios, quantification could possibly derive from IIASA's GLOBIOM model (http://webarchive.iiasa.ac.at/Research/FOR/globiom.html). GLOBIOM is a global recursively dynamic partial equilibrium model integrating the agricultural, bioenergy and forestry sectors with the aim to give policy advice on global issues concerning land use competition between the major land-based production sectors. Potential indicators were identified to cover the following future characteristics: use of irrigation, education levels, gender, production costs, daily calorie intake per capita, livestock numbers, land use types and changes (including crops and livestock), trade, livestock productions systems and access to markets.

As mentioned above, it is aimed to provide a disaggregated quantification of key indicators, such as future land use changes. This is seen as an important bridging indicator between the biophysical domain as well as the human impacts domain. Additional opportunities will be explored on how to integrate the socio-economic information on demography (population numbers, gender, level of education), economy (GDP) as well as levels of urbanization. Here we intend to largely build on the currently ongoing process in the climate change research community (SSPs), where these specific data will be integrated.

This will be integrated within the next months in the course of the HEALTHY FUTURES project and linked also to the climate model outputs. Finally the results will feed into the decision support tool, which should allow decision makers to explore future development pathways.

In summary we intend to provide the following products.

- Qualitative/storyline assessment (storylines broken down to VBDs)
    - Based on basic storylines as provided by scenario groups
- Quantitative assessment
    - Single indicator description
        - Single indicators will be presented and its future development discussed how this may impact the future vulnerability
    - Integrated future vulnerability modelling
        - Spatial modelling and downscaling of approaches
        - Regression modelling (learning from past) into the future and explore other scenario/trend approaches
        - Overall aim: future vulnerability maps
    - Integration within the overall HEALTHY FUTURES risk approach
    - Feed into the decision support system

6. Conclusion

Summarising the experience gained so far, we can conclude that the scenario approach is useful to explore different plausible futures and their potential impacts. Such information is essentially needed, especially when developing coherent risk scenarios and for the communication with different stakeholders and decision makers. It was felt that developing the storylines is a well-suited

way to engage with the target communities and stimulate a discussion and thinking process on causal relationships and also what might happen in the (near) future. Additionally, this can lead to concrete insights on possibilities to respond and prepare for changed diseases impacts. Challenges lie ahead in regard to the quantification of different indicators, especially for geographically, disaggregated ones.

Publications are also foreseen as a result of this deliverable. Jointly with the CCFAS team a publication on the adapted storylines for vector-borne diseases is foreseen in the near future. An additional focus will be given to publish the quantified vulnerability scenarios and related methodologies. Weight should also be given to the methods on how to integrate the results from the disease models and vulnerability estimations towards an integral risk assessment.

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